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ABSTRACT

The relationship between embedded support devices (ESDs) and study results was examined to determine whether ESDs have a positive effect on study outcome. Two versions of a learning unit of a governmental law course at the Open University of the Netherlands were constructed. One represented the original text and the other was about 40% shorter as a result of deleting most support devices (schemes, summaries, and learning objectives). Thirty-six students from the University of Maastricht studied one of the course versions. Tests and questionnaires were developed to measure effects of the two versions and the potential interrelation with independent variables. No effect of studying different course versions was found on study time, student evaluations of the learning access level, and "knowledge" questions. But students who studied the course version with ESDs had significantly higher scores on insight questions. Of the independent variables (e.g., prior knowledge, time used, reading comprehension, educational level, and gender) only reading comprehension had a significant effect. Three tables and two figures present study data. Two appendixes contain an additional figure and table of supporting information. (Contains 29 references.) (Author/SLD)

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Varying embedded support devices in a course: what is the effect?

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OTIC RESEARCH REPORTS.

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The main objectives are in the field of flexible organization of support, incorporation of support into learning materials, optimizing the link between student characteristics and the support needs, and the development of more flexible (and automatised) approaches towards student guidance.

Centre for Educational Technology and Innovation
Open university

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OTIC Research Report 44

R.L. Martens
P.H.A.G. Poelmans
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M.M.A. Valcke

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Abstract

In this investigation the relation between embedded support devices (ESD) and study results is investigated. The key question is: do ESD have a positive effect on study outcome? Two versions of a learning unit (chapter) of a course of the Open university of the Netherlands named 'Introduction to governmental law' were constructed. One was an almost exact copy of the original course text. The second version was approximately 40% shorter as a result of deleting most support devices (such as schemes, summaries and learning objectives). This was done without omitting basic information or affecting the coherence of the text. Thirty-six students from the University of Maastricht (RL) studied one of both course versions. Several tests and questionnaires were developed to measure the effects of course versions on the study results and the potential interrelation with independent variables.

No effect of studying different course versions was found on study time, student evaluations of the learning access level and 'knowledge' questions. But students who studied the course version with ESD obtained significantly higher scores on 'insight' questions. Interrelations with the independent variables: prior knowledge, time used, reading comprehension, educational level and gender were tested. These variables were added to the ANOVA models as covariables. Only reading comprehension turned out to have a significant effect.

1 Introduction

In a context of distance education the quality of study materials is of prime importance. The study materials of the Open university of the Netherlands (Ou) are still mainly text-based. Much energy and time is invested to generate these materials. An essential part of the printed study text consists of embedded support devices (e.g. content pages, examples, advanced organizers, pre- and postquestions, schemes, tests, margin texts). Embedded support devices (ESD) are defined as formal and/or content-related add-ons, extensions and elaborations of the learning content in printed study materials. They aim at scaffolding the learning process by supporting orientation, planning, processing and evaluative aspects of the individual learning process.

The project 'Course Versions' (Cursusvarianten) of the Centre for Educational Technology and Innovation (OTIC) focuses on the effects of course versions on study outcomes. Especially, the effect of varying the amount of ESD is of main interest. The key question of this project is: "Is the high investment in the design and elaboration of printed study materials worth the effort?" Where earlier research focused on researching the actual use of ESD, the key questions of the 'Course Versions' project are related to the 'effects' of ESD on study outcomes/results.

The research method used in our earlier research was based on questionnaires and interviews (see section 2 for more information). An important disadvantage of these two methods however is that they demand introspection and reflection on cognitive functioning. A great deal of the study process takes place at a subconscious level (Resnick, 1987). Using interviews or printed questionnaires therefore incorporates the risk of underestimating or mistaking functions and effects of ESD. Just & Carpenter (1977, p.1) state: "For most adults, comprehension is rapid, automatic and effortless. But, despite of its apparent simplicity, comprehension includes a myriad of subprocesses, each of which by itself constitutes a formidable computational task. (...) All these processes occur so quickly that their richness is underestimated. Because of the sheer speed of comprehension, it is difficult for the reader to explain how he came to understand a passage. That task is left to those who study comprehension."
It is difficult to get access to study processes by means of an interview or questionnaire. To overcome this problem other research methods are needed. Two alternatives are the eye-movement registration method or measuring product outcomes, e.g. study results. The eye-movement registration method is in this perspective very efficient since the attentional focus of students on specific text parts is registered, without the student being conscious about this. Focusing on product outcomes can consist of measuring what and how many students recall and comprehend after studying a text. We used in the actual research both different methods. The research based on the eye-movement registration method will be reported separately. The research in this report focuses on the effect of ESD on study results and text comprehension. To use this research method we developed two versions of a study text: a study text with embedded support devices and one without embedded support devices.

This research report continues with chapter 2 where an overview of earlier research is presented. Chapter 3 includes a summary of the general theoretical base and background in order to present in a coherent framework the research hypotheses. Chapter 4 focuses on a description of the research design. Attention is paid to the careful selection of the research population, the development of the course versions, the research instruments, the research procedure and the processing of the data set for further analysis. An analysis of the research data based on ANOVA is presented in chapter 5. In chapter 6 we discuss the results and present some conclusions.

2 Earlier research

This section focuses first of all on earlier research conducted outside the context of the Ou of the Netherlands. It thereby presents some general results of this research body and especially indicates some important shortcomings of this research. In a second subpart an overview of research conducted at the Ou of the Netherlands is presented.

2.1 Research conducted outside the Ou of the Netherlands

Limited amount of research
Clyde and Crowther (1983, p.4) clearly point at this shortcoming when they state: "Despite the growth of distance education, little systematic knowledge is available concerning the ways in which students use the distance teaching materials provided to them." (cf. also Marland, Patching, Putt & Putt, 1990). Despite the high investment in ESD by course developers, little is known about there functions and effects in study materials. This is particularly true if we focus on research in a 'distance education' context.

Doubts about functions and effects of ESD
Most ESD are designed to evoke some kind of behaviour of students. Wade and Trathen (1989, p. 40) however state: "(...) despite their popularity, there is no consistent empirical evidence that these techniques are any more effective than more passive methods of reading-only or repetitive reading...". Even when - from a theoretical point of view - functions and effects are assigned to specific ESD, there is the problem that Meyer and Watson (1991) have signalled: practical implications derived from this are often not useful.

Use of ESD
Many research on ESD is marred by the fact that researchers hardly know what learners do when they are presented with text-embedded support. It is for instance not sure whether or not they use or know how to use these support facilities (c.f. Winne, 1983). We may not forget that the student - when working at a distance with printed learning materials - has complete veto power over learning (Rothkopf, 1970, p.326). Winne (1983, p.245) states for example when he tries to explain the inconsistencies in earlier research results : "these results may reflect different ways that learners cognitively responded to the instructional stimuli rather than weaknesses in their effects". In order to obtain more valid results, this researcher trains his students to use the embedded support devices (objectives, adjunct postquestions). A similar approach is adopted by Bernard (1990) (c.f. de Jong & Simons 1988, p.178).
The question is not only whether students use the support devices or whether they know how to use them, but also whether they need the support provided. They are only useful if students need them. Waller (1979, p.180) mentions e.g. different user objectives when dealing with study texts: entertainment, recapitulation/reviewing, browsing, studying in depth, searching for a particular item, etcetera. Each user perspective affects the potential effects/functions of ESD.

Methodological problems
Valcke & Martens (1992, p.8-9) stated that the ecological validity of many research set-ups can be questioned. Research is hardly set up in a distance education context or at least in a natural context. Most research is set up in isolated lab-like settings.

Theoretical problems
Finally, serious theoretical problems can be put forward when analyzing the research in the literature. Valcke & Martens (1992) signalled a lack of theoretical base, reductionist approaches and

behaviouristic influences. They indicated also the fact that potentially important variables are excluded from theoretical models, conceptions and approaches.

2.2 Research at the Open university of the Netherlands

At the Dutch Ou, research in relation to ESD has been set up since 1991. We shortly describe some of the research-approaches and a subset of the results.

Theoretical framework
A basic phase in the Ou-research was the elaboration of a theory on the potential functions and effects of embedded support devices in printed study materials (Valcke & Martens, 1992). This theoretical model is considered as a starting point from where to look at the actual use of ESD by students when they study the course materials.
In reviewing the literature, also methods and instruments were examined to investigate the use, functions and effects of embedded support devices.

Checklist
A checklist was developed to map the occurrence and quality of ESD in a study text, at course and at learning unit level (Valcke, Daal, Martens & Dochy, 1991).
This checklist was used in a try-out with the course 'Introduction to Governmental Law' and proved to be useful for systematic mapping ESD (Martens & Daal, 1992; Martens, Daal & Valcke, 1991).

Research with interview method
In a first research set-up 25 law students of the Ou were interviewed extensively about their study and the use and effects of ESD (Poelmans, Martens, Daal, Valcke & Dochy, 1992; Valcke, Martens, Poelmans & Daal, 1993). The interview method had the advantage to reveal considerable and detailed information. However interviewing students, transcribing, analyzing and categorizing the student answers was very time-consuming. This implied to restricting the number of interviewees: 25 law students. Conclusion of this research indicated that ESD are used and highly appreciated by students. Furthermore students who use ESD received significantly higher final test scores and needed less attempts to take the final test.

Research with the questionnaire method
At the Ou of the Netherlands an annual evaluative study of the department Education and Evaluation (Onderwijs en Evaluatie or O&E) involving about 2000 students is set up and is always based on questionnaires. Students taking courses in different subject domains participate in the study. In the year 1992 a part of this questionnaire consisted of questions about embedded support devices, their use and links with study success. In subsequent research this part of the questionnaire was used. With this instrument compared to the interviewmethod a greater amount of students could be contacted. Researchers of O&E and OTIC analyzed the student answers (Martens, Poelmans, Daal, van Staa & van Meurs, 1993). This research revealed that ESD are extensively used and highly appreciated. Only students of the subject domain Cultural Sciences appreciated ESD to a lesser extent. No interrelation with the use of ESD and study success could be found. Study success was operationalised as the speed to attain study credits.

3 Theoretical background

This section summarizes the theoretical base of this research. First of all key processes and variables are presented. These are in section 3.3 integrated into one consistent theoretical model. We refer to Valcke & Martens (1992) for a more extensive description and discussion.

3.1 Cognitive psychological framework

Much effort was invested in developing a theoretical framework about embedded support devices in relation to studying from printed texts. An essential part of this theoretical framework is based on considerations about the nature of cognitive functioning. We opted for instance for the componential theory of Sternberg (1985, 1988) to describe and explain cognitive functioning in our specific distance education context. Sternberg's cognitive processing approach stresses, in one consistent framework, the importance of a large complex of cognitive processes. The theory can be linked to intra-individual variables and particularities of the instructional setting of the Open university: distance education, self-instruction, independent learning, etcetera.

Cognitive functioning is - according to Sternberg - described with the concept 'components'. A component is "an elementary information process that operates upon internal representations of objects or symbols" (1986, p.225). Sternberg distinguishes three groups of components:

- Performance components (PC);
- Knowledge acquisition components (KAC);
- Metacognitive components (MC).

Metacognitive components control, evaluate and plan the activities of the other components. They are executive processes. The knowledge acquisition components are involved when new information is integrated in already available information in memory. This integration process implies encoding, combining and comparing. Performance components are those processes that operate when a task is actually executed. Knowledge acquisition and performance components are non-executive processes. The metacognitive components can be perceived as "the stage directors that tell the actors - the performance and knowledge acquisition components - how to act. The actors in turn provide feedback to the directors about how the show is going. (Sternberg, 1988, p.189)".

3.2 Reading: an intervening process

In our conception of independent learning at a distance, major importance is paid to the in-built support in the printed study materials. We prefer to describe the learning process as a recursive process in which cognitive operations continuously interact in a network.
In our view, ESD influence specific (sets of) cognitive processes and can therefore result in a positive effect of exhort a specific function.
The interference of the reading process in our research cannot be neglected and is even to be incorporated into our model. We thereby focus on those aspects of the reading process that are related to studying, learning. As a consequence we did especially focus on the comprehension of printed texts (discourse comprehension) and not on the decoding aspects of the reading process. (discourse).

3.3 Other variables

Other variables of importance are:
- non-cognitive aptitudes such as motivation
- task environment: the task environment refers to those variables that define the setting in which the student studies. These variables show a great variability in a distance education setting.
- individual variables: individual variables such as prior knowledge also play an important role in the study process.

Figure 1 summarizes the theoretical framework.

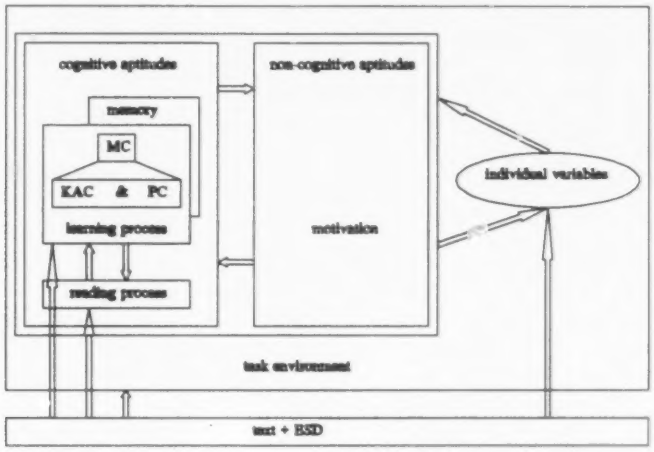

Figure 1: A model for learning from printed study materials

3.4 Towards a research model

The model in Figure 1 is useful to derive hypotheses for specific research set-ups. In the study reported here, we investigate the effect of ESD on study outcomes. We constructed two course versions: one with the 'normal'[1] set of ESD and one with as few as possible.
Study outcomes as a result of studying one of the two versions were measured in 3 different ways:
- time used for studying,
- comprehension of the studied learning unit. The comprehension score will be split in two components: a score for insight and a score for knowledge,
- Student rating of Learning Access Level (LAL)

Considering the theoretical framework, intervening variables can play a major role. Despite the complexity of these variables a specific set of such variables are included:
- reading comprehension
- individual variables: Previous research indicated that gender, prior knowledge and educational level are important in relation to studying in distance education (Poelmans et al, 1992; Valcke et al, 1993; Dochy, 1992). Time used for studying is not only considered as

[1] 'Normal' refers to the amount of ESD normally included in the original learning unit of the course.

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a result of the text version used (dependant variable) but also as a student characteristic: some people tend to study (read) longer than others. In the latter case the time used to study the course text can be treated as an independent variable. We have approached this variable in both ways.

Note that in the research model (Figure 2) no distinction is made between the components of the learning process (MC, KAC, PC). In this investigation we regard the learning process as a whole.

Linking the former to our theoretical model, the following more operational 'research model' can be presented:

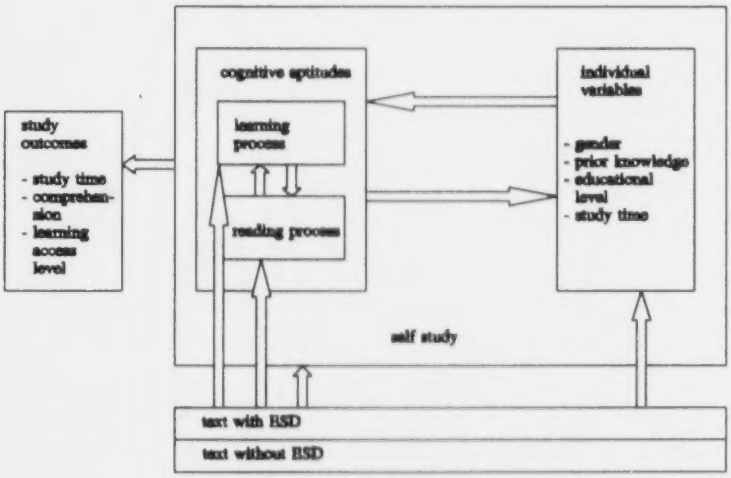

Figure 2: Research model

Translating this research model to practice implies the following. As described in section 2.2 in earlier research (Poelmans et al, 1992; Valcke et al, 1993) we found that the use of ESD improves study success. It also was found that ESD are highly appreciated. However ESD take a lot of place (about 40%) of the total content of Ou course materials (see section 4.1 for a detailed description), so it can be expected that studying a text with less ESD takes less time. This reasoning is false if the supporting functions of ESD can decrease study time. In that case no differences in study time between the two versions are expected.

Considering this, the following hypotheses will be tested. These hypotheses are formulated as scientific hypotheses that are to be rejected

Research hypotheses

1. Studying from text without ESD (short version) leads to more comprehension of the learning unit (knowledge and insight).
2. Studying from text with ESD (long version) leads to less time spent on studying.
3. Studying from text with ESD (long version) leads to lower appreciation from students of the learning access level (LAL).

The impact of the following 5 *intervening* variables will be taken into account:

- reading comprehension
- gender
- prior knowledge
- educational level
- study time

4 Research design

In this research design we decided to focus on product outcomes: what and how many students recall and comprehend after studying a text, and is there a difference in time used for studying and in student ratings of learning access level. To set up this research design we (1) developed two versions of a study text: a study text with and without embedded support devices, (2) defined a research sample of students, (3) developed research instruments and (4) composed a research procedure. We end this section with subparts focusing on the quality of the research instruments used and the research data obtained.

4.1 Two versions of a learning unit of the course 'Introduction to Governmental Law'

Two versions of one learning unit of the course 'Introduction to governmental Law' were developed: an 'extended' and a 'short' version.
The 'extended' version resembles the learning unit of the course as published by the Ou. Only a few adjustments were added to make it possible that students can study this specific learning unit apart from the other learning units in the course. Prior analysis (Martens & Daal, 1992; Martens et al, 1991).reveals that the learning unit selected for our research can be considered as representative for the learning units in this particular course. A learning unit is estimated to take about 4 hours of study time for a novice learner.
The 'short' version contains almost no embedded support devices. All embedded support devices that can be easily eliminated without affecting the coherence of the learning unit content are removed. Embedded support devices that are of importance for the coherence of the study text or that contain basic information are not removed. As a result only the ESD are removed that can be disconnected from the basic text. The amount of removed ESD consists of almost 6 of the 15 original pages (40%). Table 1 contains an overview of the type and number of the embedded support devices that have been removed. In appendix A a page from both versions is included to give the reader an impression of the important differences between the two text versions.

Table 1: Type and number of removed embedded support devices

embedded support devices	number
content page	1
learning objectives	1
italics	12
margin text	24
scheme	3
example	11
summary	1
feedback	4
question	4

The text reductions as a result of removing the ESD do not decrease the amount of 'governmental law information'. In our opinion, the omission of the ESD affect study-process features such as:

orientation, planning, processing and testing. But, also information about links of the law content to 'real life' is cancelled by removing the examples.

4.2 Research sample

This research involves students taking courses in the law domain of the Ou of the Netherlands. But, students in a distance eduction context are difficult to reach for research purposes (due to travel time and the combination of work and study tasks). For this research we therefore selected a comparable sample of students from a population studying at a non-distance university, the university of Maastricht (RL). Despite the differences in study context, these students are experienced with self study because of the educational system they are involved in (problem oriented learning). Moreover, before the start of the experiment, the research sample was given a short introduction about functions and effects of ESD and the organization of Ou course material. By means of advertisement first year law students were asked to participate. A letter was sent to these students who wished to take part, confirming the date and place for the research. Thirty-six students enter this research. This sample consisted of 16 male and 20 female students. The mean age of the students was 20 years. All students had prior knowledge of the study field 'Governmental law' at an introductional level.

4.3 Research instruments

Considering the amount of variables in our research model, a variety of research instruments was developed to gather specific information/data:

- to obtain a measure for the co-variable 'reading comprehension' we constructed a reading comprehension test;
- prior knowledge of the law domain was tested with a prior knowledge state test;
- the co-variables gender and educational level were extracted from part A in the questionnaire;
- study outcomes were measured with a comprehension test 'Governmental Law'
- the determination of Learning Access Level (LAL) was based on part B of the questionnaire;
- the variable 'time' was measured by recording the time subjects took for studying the course.

More details on each specific instrument are given in the following section.

4.3.1 Reading comprehension test

in the section on the theoretical base it was already indicated that reading comprehension is an important component of our model for learning from printed study material. To measure reading comprehension different possibilities are available:

- self-ratings: The student is asked to value his own reading comprehension. Possible questions are "How many pages do you read in one hour?" or "Do you skip an article in the paper, because you didn't understand it?" Answering these questions is not easy. Students interpret these questions in different ways. There is also the possibility that students give socially desirable answers.
- administering an existing reading comprehension test: The problem is that no Dutch reading comprehension test is available at academic level. Research is currently done in this field by de Geus, Henneken and Rietsma (1992) but no results/instruments are available at this moment.
- a test in a different language: translation of a test developed in a different language. Translation is difficult and affects the reliability of the new 'translated' test.

- developing a new test: Regarding the disadvantages of the former possibilities, developing a new test is the only acceptable alternative. For this research a reading comprehension test at academical level was developed. The first version of the test consisted of 23 text fragments (e.g. texts of courses of the Open university). Each text was followed by two propositions about which a student had to judge the congruence with the text. A try-out of the test resulted in few adjustments. The new test version was probed and adjusted anew. This resulted in a final version consisting of 22 text fragments. This version of the test had a reliability rate of .69. For a detailed description of the development of this test, we refer to Martens (in prep.)

4.3.2 Prior knowledge state test Law

To measure the prior knowledge state in relation to the law domain, an adjusted version of a final test for the 'Basic course Law' was developed. This was done in close collaboration with a law-expert. The number of test items was reduced and several items were rewritten. The final test consisted of 32 items: 20 multiple choice questions and 12 true/?/false questions.

4.3.3 Questionnaires

The questionnaire comprised three different parts:

Part A consisted of general questions about motivation, age, study habits, educational level, gender etcetera.

Part B contained questions about the course text version a student studied. Students are asked to judge the clarity, view and difficulty of the text version on a five points scale. These ratings give an indication of what we call the rating of the Learning Access Level (LAL) of the text version.

Part C included questions about embedded support devices. The embedded support devices of the extended version of the learning unit were reviewed one by one. These questions focuses on the use of the support devices, their appreciation and their functions and effects. Part C is only relevant for those students who studied the 'extended' version.

4.3.4 Comprehension test Governmental Law

The comprehension test measures the mastery of the objectives pursued by studying the specific learning unit. The original version of the learning unit comprised a test, consisting of open-ended questions. These questions were used as a base to develop a final test for the experimental versions. The final test consists of 23 questions: 16 true/?/false questions and 7 multiple choice questions. Analyzing these questions from a didactical perspective two subsets of about the same length can be distinguished:

- knowledge questions (13) checking the straightforward recapitulation of certain domain aspects
- and insight questions measuring a more thorough insight in the domain (10).

The test covered in a balanced way all learning objectives pursued in the learning unit.

4.4 Research procedure

The research took place during two half day-periods. The location was an auditorium of the university of Maastricht. The following procedure was used:

- The first half-day period 47 students participated. The reading comprehension test, the prior knowledge state test and part A of the questionnaire were administered.

- After the first research session we analyzed the data obtained. The results of the prior knowledge state test were used to match two groups of students to be involved in the next research activities. Two levels of prior knowledge were considered in this matching procedure: high and low prior knowledge.
- Two weeks after the first session the students were invited to participate in the second session. The research population consisted of 36 students[2] of which 18 studied the 'extended' version of the learning unit; the other 18 studied the 'short' version. As stated earlier, these two groups were matched considering their prior knowledge level. During the session students studied one of the two versions. The time students spent studying the learning unit was recorded. After studying the learning unit students were asked to solve the comprehension test and answer part B and C of the questionnaire. To motivate the students an extra financial reward of 25 Dutch guilders was promised to the two students with the best comprehension test score.

4.5 Preparation of the data-set

To analyze the data a codebook was compiled describing how the student responses were to be coded in an unambiguous way. This resulted in a set of 181 research variables. The data set was entered into the computer to be processed with the SPSS^{PC} statistical package. Scores for several variables were obtained by following this process:

- Scores of respectively the prior knowledge test, the reading comprehension test and the comprehension test Governmental Law were computed. This resulted in three variables: total score of prior knowledge, total score reading comprehension and total score comprehension Governmental Law. The comprehension test governmental Law consisted of 'knowledge' and 'insight' items. The sub-score for 'knowledge' questions and 'insight' questions was also computed. The variables which gave an indication of the use of a specific embedded support device were as well computed. The new variable gives an indication of the general use of embedded support devices.
- The variable 'student rating of Learning Access Level' (LAL) was constructed by combining the ratings to the different items of questionnaire B.

A set of variables was recoded to reduce the amount of response categories:

- The reading comprehension score and prior knowledge Law score were recoded into two groups: high versus low prior knowledge and high versus low reading comprehension.
- The variable 'general use of embedded support devices' was also recoded into two categories: much versus little use of embedded support devices (by means of frequency analysis we made sure that the categories contained about the same number of students).
- The time spent studying the learning unit was recoded into three different categories: (lowest thru 42 minutes = 1), (43 minutes thru 52 minutes = 2) and (53 minutes thru highest = 3).
- The variable 'educational level' was recoded into two different categories: students with higher education experience and students without higher education experience.

4.6 Reliability and validity of the research instruments

Next to a screening related to the ANOVA-assumptions also the determination of validity and reliability measures of the research instruments is needed. The following considerations are important in this perspective:

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[2] From the initial sample (N=47), eleven students participated in a separate research set-up, involving eye-movement registration. Results of this research are reported elsewhere.

- All items of the reading comprehension test should measure the same aptitude (internal consistency). Items that correlate negatively should not be part of the test. Crombach's alpha of the remaining items should be at least .65.
- The comprehension test and the prior knowledge test consist of two or three subsets of items testing different mastery levels (knowledge versus insight/apply). Internal consistency is not expected to be high because of the quite different subjects of the questions. Before calculating Cronbach's Alpha, both tests have been split into subparts.

We discuss the results by reviewing each research instrument separately:

- Reading comprehension
  After deleting all items with negative correlation with the total score, 29 items remained. Crombach's alpha was .68 (standardized).
- Learning access level (LAL)
  A total score of the student rating of learning access level (LAL) was computed by adding all scores of part B of the questionnaire together. No item-analysis was preformed.
- Prior knowledge test
  We indicated that internal consistency is expected to be low, considering the special nature of this test. The reliability coefficient of the knowledge questions was .14 (17 items), for the insight questions it was .18 (12 items) and for the apply questions (which is a special case of insight questions) it was -.40 (3 items). No further reliability analysis was performed. The content validity was ensured by choosing/adapting an existing test in cooperation with an expert in the law domain.
- Comprehension test
  We repeat here the problem mentioned in relation to the prior knowledge state test. Internal consistency is expected to be low, considering the special nature of this test. The reliability coefficient of the knowledge questions was .12 (13 items), and for the insight questions it was .08 (10 items). Again no further reliability analysis was performed. The content validity was also ensured by choosing/adapting an existing test in close collaboration with a law expert.

4.7 Some special variables

Two variables in this research have to be discussed separately: time and use of the embedded support devices.

Time is not only to be considered as a result of the text version used (dependent variable) but also as a student characteristic: some people tend to study (read) longer than others. In the latter case the time used to study the course text can be treated as an independent variable. We have approached this variable in both ways.

We also administered a small questionnaire about the use of ESD as perceived by the students. Since only students who studied the version with ESD could answer these questions we only have data from one from the two groups. Therefore the questionnaire only had an explorative function and will not be referred at in the results section.

4.8 Test statistics

The analysis technique used in the following section is analysis of variance. Considering ANOVA as the statistical technique to be used, especially assumptions have to be met in relation to the dependent variables.

To make sure that the general assumptions for executing an analysis of variance are met, the

following tests have been used:

- Cochran Bartlett test for homogeneity of variance of the dependent variables.
- Normal plots of the distributions of the dependent variables.
- Kolmogorov-Smirnov Goodness of fit test to check the assumption that the dependent variables are approximately normally distributed.
- Bartlett Test of sphericity. If the dependent variables are uncorrelated ANOVA instead of MANOVA must be used (Norusis, 1988).

The results indicate the following. The variances are significantly unequal. All dependent variables are approximately normally distributed. Since there are no significant correlations between the dependent variables ANOVA in stead of MANOVA will be used. This means that the inequality of variances is no longer a problem (For the exact figures we refer to appendix B).

The scores for each test, related to independent variables, were screened for outliers. No problems were met.

5 Results

5.1 Introduction

In this section the results of the analysis of variance will be presented. We will investigate which hypotheses can be rejected based on the analysis of the results. The influence of 5 intervening variables will be checked by means of matching and/or analysis of covariance.

5.2 Analysis of variance

First the results of the analyses of variance are presented. Next, we focus on the influence of the covariables. We will examine if changes occur in the main effects as stated below.

Table 2: Effects of version (ANOVA; n=36; oneway probability)

variable	average short version	average long version	degrees of freedom	F-value
LAL	46,17	46,50	1; 34	.024
time	46,50	51,56	1; 34	.901
insight	6,44	7,56	1; 34	3.47*
know	8,00	8,28	1; 34	.167

* P<0.05

From Table 2 it can be concluded that:

- ESD have a positive effect on the comprehension of printed study texts. Students that read the 'extended' version with ESD obtain significantly higher scores on insight-questions.
- This effect cannot be explained by longer reading times of the text with ESD. Although the text without ESD was about 40% shorter, no significant differences in average reading time are perceived between the two groups of students studying different text versions. Students that study the 'extended' version need on average 51,56 minutes and those studying the 'short' version study on average 46,5 minutes.
- No significant differences are found in students ratings of the Learning Access Level (LAL).

5.3 Analysis of covariance

In the cells of Table 3 the 'new' F-values from the main effects are displayed that are assessed after adjusting for the covariables that are printed in the left collum. In this analysis a new score of the dependent variable is predicted from an 'intervening' variable.

Table 3: F-values from the main effects after adjusting for covariables
(d.f. 1,35; n=36; oneway probability)

(co)variable	LAL	time	insight	know
gender	.062	2.22	2.9*	.167
prior knowledge	.014	.850	4.64*	.268
time	.004	--	3.7*	.177
reading comprehension	.096	1.29	2.61	.099
educational level	.099	.665	3.0*	.131

* P<0.05

From Table 3 can be concluded that there are almost no significant changes of the main effects: only when reading comprehension is used as a covariable there is no longer a significant relation between version and score on insight questions. Reading comprehension is therefore an intervening variable that influences the score on a test for comprehension.

Both student groups in the research design were matched according to their prior knowledge. Therefore the results indicate that prior knowledge turns out to be an intervening variable of little importance. Gender, educational level and time also seem to have no significant impact.

The results in Table 3 must be interpreted with caution because it is difficult to meet with all the assumptions underlying the ANCOVA model (e.g., error free measurement of the covariable). Also, the changes in significance level are very small. The p-value from the main effect, when corrected for reading comprehension is still p = 0.058. It must also be kept in mind that the reliability of the reading comprehension test was low (Alpha .68). Inspection of the correlations between all the variables used, showed that there was only one significant correlation: female students tend to study longer than male students (r=.50; P<0.01). There was no significant correlation between reading comprehension score and the score on insight questions of the comprehension test (r=.24). Therefore we conclude that reading comprehension is a significant intervening variable in this study, despite the randomization of the groups, but that its influence is to small to reject the effects printed in Table 2.

6 Discussion and conclusions

Considering the results in Table 2, conclusions can be presented in relation to the research hypotheses: hypothesis 1, 2 and 3 can be rejected:

1. Studying from text without ESD ('short' version) leads to more comprehension of the learning unit (knowledge and insight).
2. Studying from text with ESD ('extended' version) leads to less time spent on studying.
3. Studying from text with ESD ('extended' version) leads to lower appreciation from students of the learning access level (LAL).

Considering the analysis of co-variance (Table 3), the independent variable 'reading comprehension' can be retained as an important intervening variable.

In our opinion the results found are not surprising. They are in line with results previously found:

- Poelmans et al. (1992) and Valcke et al. (1993) showed that students use ESD, that they appreciate ESD positively and moreover that using ESD is related to better study results (higher scores on examinations and less attempts required to get a sufficient result). This research was based on interviews with 25 students.
- The results found in this study are also in line with Martens et al. (1993) and van Staa & van Meurs (1992) who showed also that students do use and appreciate ESD. However studies, based on questionnaires (N=1159), showed no interaction with study results. They argue that this is probably due to different operationalisation of the variables and/or a different research design.

We found not as many interactions with student characteristics as Valcke et al. and Poelmans et al. This might be due to our research design. First, student characteristics were only measured by -short- questionnaires. Second, our research population was relatively homogenous. This might mask the impact of certain relations. The rationale for selecting this specific sample of students was based mostly on the fact that students in a distance education context are hardly available for this kind of research.
Nevertheless, one covariable had significant effects on the results: reading comprehension. Future research is needed to find out to what extent reading comprehension is an import variable in distance eduction, alike for instance prior knowledge (Dochy, 1992). To make more solid conclusions on this subject further improvement of the reading test (alpha) is required.

In general we conclude that this investigation revealed information about the relations between the variables as displayed in Figure 2. These relations were in the directions we expected.

As to the two study text versions used in the research design, some critical remarks can be made that also can explain some results. Both versions were based on the original Ou-materials. This implied that we didn't change or optimize the quality of the ESD in the text. A thorough investigation of the material showed that some critical remarks could be made about the way ESD were implemented in this course (Valcke et al., 1991; Martens et al., 1991; Martens & Daal, 1992). It is possible that improving the quality and increasing the quantity of ESD in the course would strengthen the positive effects perceived. Nevertheless, the results found support further investment in research and practice on ESD in study texts for distance education learning materials.

This study focused on 'printed' study materials. Despite the fact that 'print' is still a predominant mode of delivering the educational materials, further developments are on their way. Printed materials are not 'flexible', the embedding of the support devices cannot be varied easily according to student needs or demands. More flexible learning materials, delivered in an electronic way,

open prospects for further developments in this field. At this moment research is carried out at the Ou of the Netherlands. Among others Portier & Valcke (1993) have for instance developed a prototype of a flexible and interactive learning environment. In this learning environment, embedded support devices can be added to or removed from the study text in a flexible way depending on student needs/demands.

Finally, when adding the results of this study to these of previous studies a more clear picture starts to arise about the potentialities of ESD: investing time and money in the implementation of ESD seems worthwhile since ESD are used and seem to have a positive effect on study outcomes.

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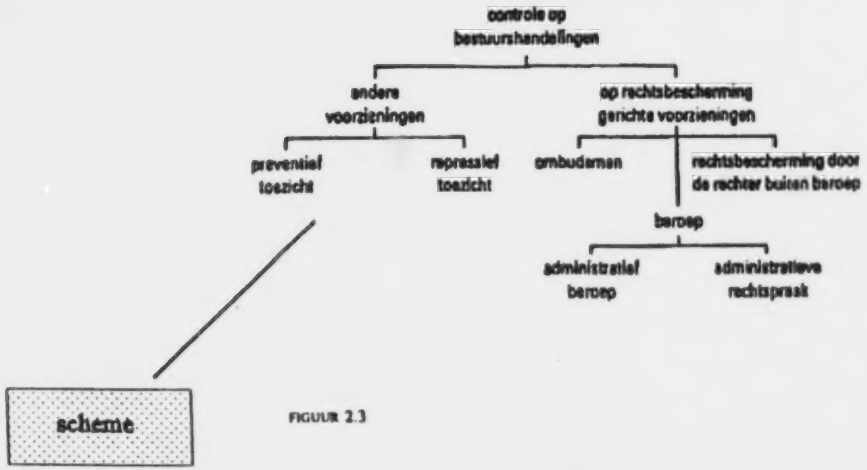
version A 'long version'



FIGUUR 2.3

scheme

rechtsbescherming

ombudsman

margin text

administratief beroep

administratieve rechtspraak

civiel proces tegen

Naast voorzieningen die bestuursorganen de mogelijkheid bieden op eigen initiatief onjuist of onrechtmatig geachte besluiten van lagere organen te voorkomen of te vernietigen, zijn er op *rechtsbescherming* gerichte voorzieningen. Daarmee doelen we op regelingen die de bestuurde kan hanteren om een uitspraak over de juistheid of rechtmatigheid van een bestuurshandeling uit te lokken. Zo kan bijvoorbeeld de Nederlandse staatsburger sinds 1 januari 1982 een klacht bij de *ombudsman* deponeren. Deze beperkt zich echter tot een onderzoek naar de juistheid van de klacht en het rapporteren van zijn oordeel. Een echte mogelijkheid van beroep is het dus niet, want de ombudsman kan een onjuist of onrechtmatig bevonden besluit niet vernietigen, noch kan hij de administratie tot betaling van schadevergoeding verplichten.

Er bestaan ook organen waar de burger een klacht kan deponeren die wél vergaande bevoegdheden hebben om maatregelen te nemen. Meestal kunnen ze het bestreden besluit vernietigen als ze de klacht van de burger terecht vinden. De regelingen die voor de bestuurde zo'n recht van beroep openen, vallen in twee categorieën uiteen. Er zijn wetten die beroep mogelijk maken op een orgaan van het bestuur (bijvoorbeeld op de gemeenteraad tegen een besluit van burgemeester en wethouders). In zulke gevallen spreken we van *administratief beroep*. Andere wetten openen beroep bij een rechterlijke instantie (bijvoorbeeld de afdeling rechtspraak in AROB-zaken). Dan spreken we van *administratieve rechtspraak*.

Ten slotte bestaat er ook nog rechtsbescherming die door de rechter wordt geboden buiten het kader van een wettelijke beroepsregeling. Denkbaar is bijvoorbeeld dat een aardappelleverancier een prijsmaatregel, waarbij een maximumverkoopprijs is vastgesteld, onrechtmatig vindt en daarom een *civiel proces tegen de overheid* aanspant. De burgerlijke rechter komt dan

italics

version B 'short version'

Naast voorzieningen die bestuursorganen de mogelijkheid bieden op eigen initiatief onjuist of onrechtmatig geachte besluiten van lagere organen te voorkomen of te vernietigen, zijn er op rechtsbescherming gerichte voorzieningen. Daarmee doelen we op regelingen die de bestuurde kan hanteren om een uitspraak over de juistheid of rechtmatigheid van een bestuurshandeling uit te lokken. Zo kan bijvoorbeeld de Nederlandse staatsburger sinds 1 januari 1982 een klacht bij de ombudsman deponeren. Deze beperkt zich echter tot een onderzoek naar de juistheid van de klacht en het rapporteren van zijn oordeel. Een echte mogelijkheid van beroep is het dus niet, want de ombudsman kan een onjuist of onrechtmatig bevonden besluit niet vernietigen, noch kan hij de administratie tot betaling van schadevergoeding verplichten.

Er bestaan ook organen waar de burger een klacht kan deponeren die wél vergaande bevoegdheden hebben om maatregelen te nemen. Meestal kunnen ze het bestreden besluit vernietigen als ze de klacht van de burger terecht vinden. De regelingen die voor de bestuurde zo'n recht van beroep openen, vallen in twee categorieën uiteen. Er zijn wetten die beroep mogelijk maken op een orgaan van het bestuur (bijvoorbeeld op de gemeenteraad tegen een besluit van burgemeester en wethouders). In zulke gevallen spreken we van administratief beroep. Andere wetten openen beroep bij een rechterlijke instantie (bijvoorbeeld de afdeling rechtspraak in AROB-zaken). Dan spreken we van administratieve rechtspraak.

Ten slotte bestaat er ook nog rechtsbescherming die door de rechter wordt geboden buiten het kader van een wettelijke beroepsregeling. Te denken valt aan een aardappelleverancier een prijsmaatregel, waarbij een maximumverkoopprijs is vastgesteld, onrechtmatig vindt en daarom een civiel proces tegen de overheid aanspant. De burgerlijke rechter komt dan

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Appendix B

inspection of dependent variables

test/variable	time	know	insight	LAL	variables together
Cochran Bartlett test for homogeneity of variance	.548; .157	.590; .549	.665; 1.912	.662; 1.830	boxs M 1.95* - 19.6*
Normal plots	normal	normal	normal	normal	
Kolmogorov -Smirnov Goodness of fit test (normal)	.557	.992	1.07	1.082	
Bartlett Test of sphericity					7.26 with 6 d.f.

* $p < 0.05$